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The Noise Prediction and Control for UHVDC Converter Stations

Xue-yun RUAN[a,b]*, Zhi-yuan LI[b], Hao-zheng WEI[b]

[a]*School of Mechanical Engineering,Anhui University of Science and Technology, Huainan 232001, China*
[b]*School of Mechanical and Automotive Engineering, Hefei University of Technology, Hefei 230009, China*

Abstract

The noise problem of UHVDC coverter stations which is more severe than that of HV ones, gets more and more attention. UHVDC converter stations noises mainly caused by converter transformer, smoothing reactor and capacitors and reactors of AC filter sets. Noise control measures must be taken by proper site selection, optimum general layout, sound source reduction, fully enclosed box of converter transformers, using low noise AC filter reactor and installing light sound insulation and sound barrier on walls surrounding the AC filter, etc. The noise of a UHVDC Converter Station is predicted by using the software of SoundPlan. The results show that the noise level of all the test points meets the standards after taking above measures. Both environmental benefits and economic benefits are realized.

Keywords :UHVDC;converter station;noise prediction;converter transformer;fully closed

1 Introduction

In recent years, HVDC technology in China and the rest of the world develops rapidly and has advantage on the long-distance power transmission, cross networking and power system dispatching. In HVDC transmission system, power exchange between AC and DC is finished in the converter station. In the ±500kV DC converter station in China, the noise from all kinds of devices increases the total noise level in the station site which has bad influence on the life of residents around the site. Later noise control

* Corresponding author. Tel.: 13739293940; fax: 0551-2901340.
E-mail address: ruanxueyun@163.com.

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is more difficult and has higher cost without obvious effect of noise reduction[1][2]. Especially for ±800kV UHVDC project, the noise control problem is more severer than that of ±500kV. On the one hand, with increase of voltage level and rated current of devices, because of the limitation of device manufacture level, the noise control of ±800kV UHVDC devices is more difficult than that of ±500kV; On the other hand, the scope of noise propagation is wider since devices is higher. Therefore audible noise control becomes more and more important. For the construction of special UHVDC transmission project, audible noise may become one of the important control conditions in the process of site selection and design of DC converter stations[3].

2 Noise prediction principle

The noise level of the device at the prediction point is as follows [4][5]:

$$L_{psi} = L_{wi} + D_{ci} - A_i \qquad (1)$$

Where i is the location number, D_{ci} is directivity correction. A_i is noise attenuation from the noise source to receiving point "s".

The total noise level at the noise prediction point "s" is:

$$L_{ps} = 10\lg\sum_{i=1}^{N} 10^{0.1L_{psi}} \qquad (2)$$

Where: N is the number of noise source.

From the Eqs. (1), (2), we can calculate the total noise level that superposed by multiple noise sources at one prediction point.

3 Noise control goals

The object of current study is meeting the standards at the factory bound and sensitive point by means of corresponding noise control measures. The noise control measures at factory bound and residents' sensitive point are taken respectively based on Emission standard for industrial enterprises noise at boundary (GB12348-2008) and the standards for acoustic environmental quality (GB3096 – 2008). In these national standards, the requirements of noise level at night is more restrict than that in daytime. Because the noises are generated by electrical devices' operation, the different of noise level between daytime and night is not obvious. So the night noise value is chosen for noise prediction and control in this study. The factory bound noise of converter station should be under 50 dB (A) and the residential area around converter station should be under 45dB (A).

4 Noise control measures of DC converter stations

4.1 Choosing proper location and optimizing general layout

When choosing the station site, the location should be as far as possible from noise sensitive areas such as residential area and should not have many buildings on class 0 and class 1 area in order to reducing noise control fees. If it is possible, the converter station should be built in the low ground and valleys, but it is better that there is no steep rock and the noise sensitive building around it.

To optimize arrangement of devices in the station, we should separate the devices that produce noise from sound sensitive areas as far as possible when we design the converter station. The main noise source should be put in a proper place and try to use natural terrain or converter equipment and other walls of

buildings to prevent the sound waves from travelling to sound sensitive areas. For example we can put the converter transformer substations in the middle of site and use the face-to-face layout. All the substations should be arranged between valve hall and treat valve halls as natural sound barriers.AC filters should be arranged in central area of the station which is close to walls and away from the front of station area. Big buildings are as far as possible decorated between the main noise sources and sound sensitive areas so as to block the sound waves spreading to sound sensitive areas.

4.2 Noise control of sound source

Controlling the sound level of noise source is the most fundamental and most effective way to reduce environmental noise. Developing and choosing low noise equipment (such as take the improvement machine structure, the machining process and the machining accuracy etc.) to reduce the noise level of sound generators. In noise control process, some HVDC project replaced the original reactors by low noise reactor. The effect of noise control is significant [6].

4.3 Control of sound propagating

Because sound energy attenuates along with the distance from sound source, we mainly consider that increase the distance between noise source and noise sensitive point and arrange insulation facilities between noise source and noise sensitive point (such as sound barriers, planting trees, etc al.). For UHVDC converter station, the main noise control method of converter transformer is using fully enclosed device BOX-IN [7]. For dry smoothing reactor, we can reduce noise by adding shielding layer to top and bottom. Enclosed barrels are added outside of Filters and reactors. For the walls close to AC filter field area, we usually heighten the walls and add sound insulation barrier.

5 **Case of noise prediction and analysis for UHVDC Converter Stations**

Through International general noise analysis software SOUNDPLAN, the noise of ±800kV UHVDC converter stations are simulated and the effect of control measures are verified.

5.1 The input conditions of noise prediction

The main noises of UHVDC converter stations consist of converter transformer , smoothing reactor, the cooling fan of converter transformer, filter reactors and capacitors of AC filters field, high voltage shunt capacitors and reactors, capacitors and reactors of DC filter sets, valve cooling tower equipment, air conditioning equipment and transformers for stations[8]. According to the current order situation of equipments of UHVDC converter station and the previous noise control reports of HVDC converter, table 1 lists the sound power levels and types of sound source.

Table 1 Sound power levels and noise source type of the converter equipments

Equipment	Sound power level (dB（A）)	Type
Converter transformer Y/Y	118	plane source
Converter transformer Y/delta	120	Plane source
Cooling fan of converter transformer	90	plane source

Smoothing reactor	92	point source
AC filter 11/24 capacitor C1，C2	88	line source
AC filter 11/24 reactor L1，L2	85	point source
AC filter 13/36 capacitor C1、C2	88	line source
AC filter 13/36 reactor L1、L2	87	point source
Shunt capacitors SC capacitor C1、reactor L1	85	line source
		point source
HP3 capacitor C1、C2	88	line source
HP3 reactor L1	85	point source
DC filter capacitor C1、C2、 C3	80	line source
DC filter reactor L1、L2 、L3	80	point source
Transformers	93	point source
500kv highly resistance	93	plane source
Valve cooling tower	90	point source
Outdoor air conditioning equipment	85	plane source

In software settings, the calculated temperature is 20 degrees Celsius and humidity is 60% and air pressure is 950mbar. The height of noise calculation area is 1.5m from the ground. A hard ground (cement floor,asphalt pavement) inside the station and a soft ground outside the station are considered in the similation.

5.2 Acoustic models of converter

The general of the station layout and the sensitive points distribution are shown in figure 1 and 3D model of the station can be seen in figure 2.

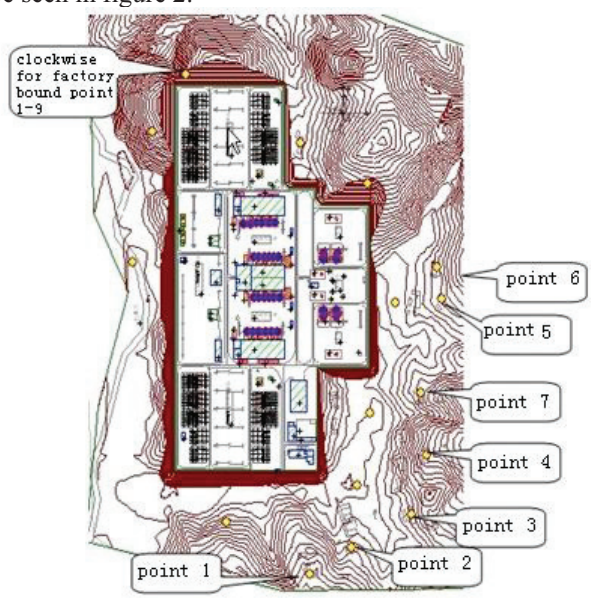

Figure 1 The general layout of and the sensitive points distribution

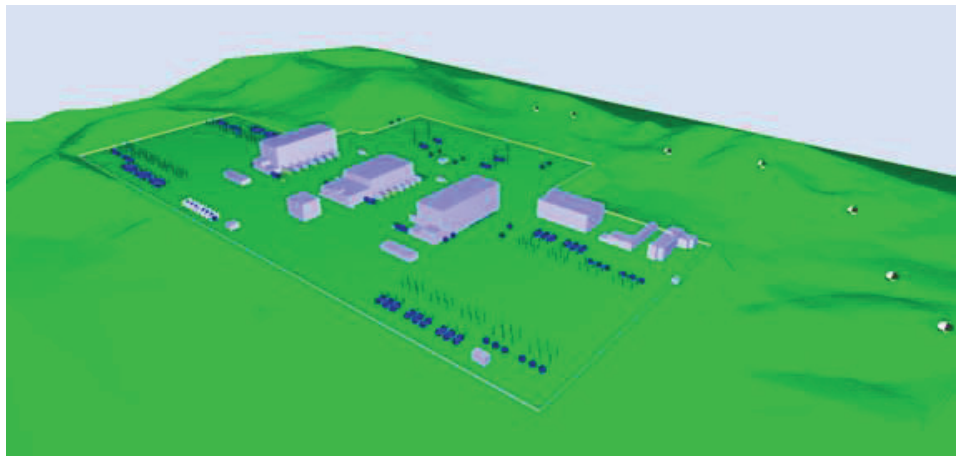

Figure 2 3D models of UHVDC converter stations

5.3 Converter noise prediction without taking noise reduction measures

Figure 3 shows total noise distribution of the station with 3 meters height fence and without taking any noise control measures. Almost all the control points outside convertor station can't meet the requirement of under 50 dB.

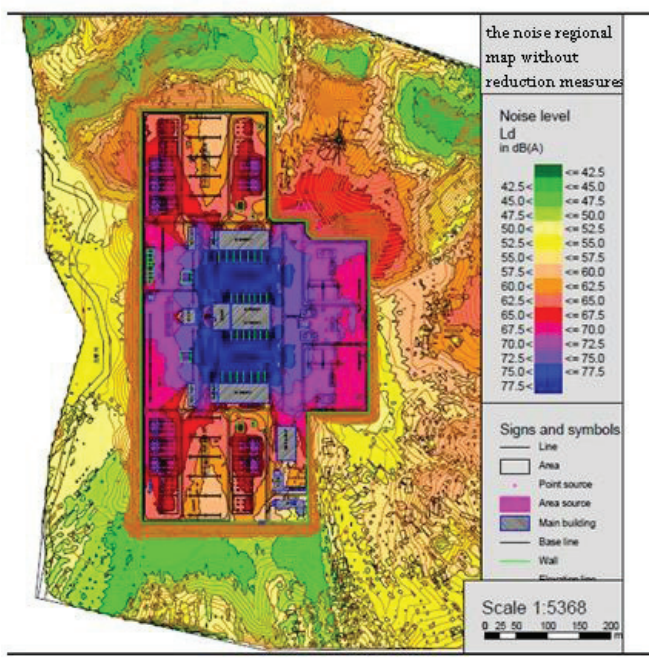

Figure 3 The noise regional map without reduction measures

5.4 Noise prediction of converter with noise reduction measures

The converter transformer use mobile and sound insulation room with ventilation and cooling muffler to enclose converter transformer. The cooling fans are put outside of sound insulation room which comes to the concept of mobile BOX - IN for converter transformer. For the wall of AC filter setting in the northeast of the station, the wall is heightened up to 6 meters with 3 meters height sound barriers on it. The top of the sound barriers is 0.5 meters cornice which is facing the sound source of station. In order to reducing the influence of the noise of AC filter sets on the station the boundary and northeastern residents. After taking above measures, the total noise distribution can be found in figure 4.

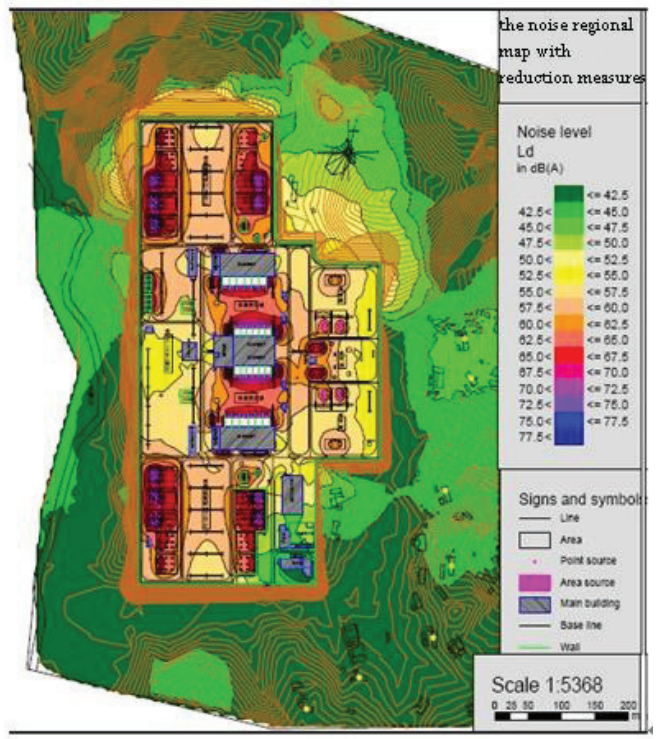

Figure 4 The noise map with taking noise reduction measures

Table 2 compares the noise level of converter stations before and after taking control measures of the single point at the factory bound and residents point.

Table 2 Comparison of the calculation results with/without taking noise reduction (dB (A))

Point	1	2	3	4	5	6	7	—	—
Without taking measures	48.5	53	57.8	59.7	63.5	63.5	60.8	—	—
BOX-IN and setting sound barrier	41.3	39.6	40.7	43.3	42.4	43.2	43.3	—	—
Factory bound point	1	2	3	4	5	6	7	8	9
Without taking measures	60.5	64.0	55.0	48.3	54.8	55.2	58.3	66.9	62.2
BOX-IN and setting sound barrier	48.5	48	44.1	42.1	39.9	42.5	39.2	49.5	49.6

6 Conclusion

In this UHVDC converter stations project, converter transformer can be fully enclosed by BOX-IN device. AC filters with low noise filter reactor, two towers layout of filter capacitor, installing sound barrier on walls surrounding AC filter, DC filter with low noise filter reactor and sound barrier around the walls etc al.are adopting in current model, Because the UHVDC project is the first project in the world, current plan of noise control for UHVDC converter stations mainly depends on previous engineering experience. Based on the situation of UHVDC converter stations, the software of SoundPlan are using to predict the noise of a UHVDC Converter Station in this paper. The results show that the noise level of all the test points meets the standards and reaches national requirements after taking above measures.

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